

## **A meta-analysis of the effect of episodic future thinking on delay discounting**

Jun-yan Ye<sup>1,2</sup>, Qing-yu Ding<sup>3</sup>, Ji-fang Cui<sup>4</sup>, Zhe Liu<sup>3</sup>, Lu-xia Jia<sup>1,2</sup>, Xiao-jing Qin<sup>1,2</sup>, Hua Xu<sup>3\*</sup>,  
Ya Wang<sup>1,2\*</sup>

<sup>1</sup> Neuropsychology and Applied Cognitive Neuroscience Lab, CAS Key Laboratory of Mental Health, Institute of Psychology, Beijing, China

<sup>2</sup> Department of Psychology, University of Chinese Academy of Sciences, Beijing, China

<sup>3</sup> Teachers' College, Beijing Union University, Beijing, China

<sup>4</sup> Research Center for Information and Statistics, National Institute of Education Sciences, Beijing, China

\*Correspondence should be addressed to Ya Wang, Institute of Psychology, Chinese Academy of Science, 16 Lincui Road, Chaoyang District, Beijing 100101, China. Tel: (8610)64881148, Email: [wangyazsu@gmail.com](mailto:wangyazsu@gmail.com), [wangya@psych.ac.cn](mailto:wangya@psych.ac.cn)

or

Hua Xu, Teachers' College, Beijing Union University, 5 Waiguan Xie Street, Chaoyang District, Beijing 100011, China. Tel: (8610)64249434, Email: [sfpsyhuax@bnu.edu.cn](mailto:sfpsyhuax@bnu.edu.cn).

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## **Abstract**

Delay discounting (DD) is the phenomenon that individuals prefer to choose an immediate but smaller reward than a delayed but larger reward. Larger DD is considered as an indicator of impulsivity, the increased DD rate is also seen as a behavior indicator of various psychiatric disorders. Episodic future thinking (EFT) is the ability to project oneself into the future to pre-experience the future events, which can be used to reduce DD. The present study provided a meta-analysis on the efficiency of EFT in reducing DD and examined potential moderators. Thirty-seven studies including 48 contrasts were included, results showed that EFT reduced DD significantly. Moderator and meta-regression analyses revealed that positive EFT was more efficient in reducing DD. In addition, several factors related to DD task (e.g., whether the DD money is hypothetical or potential real, whether the delay reward is fixed or variable, and the indexes of DD) were related to the efficiency of EFT in reducing DD. These results have implications for using EFT to reduce DD in the future.

**Keywords:** Delay discounting, Episodic future thinking, Meta-analysis

## Introduction

In daily life, people often need to make choices between short-term and long-term rewards such as choosing to enjoy the smoking for now or stop smoking and keep healthy in the future (Lempert & Phelps, 2016). During decision-making, people tend to discount the value of future rewards, i.e., they prefer to choose an immediate but smaller reward than a delayed but larger reward (Logue, 1988). The phenomenon that the subjective value of future rewards is reduced over time is known as delay discounting (DD), also called time discounting or temporal discounting (Frederick, Loewenstein, & O'Donoghue, 2002; Sellitto, Ciaramelli, & di Pellegrino, 2011). DD is considered as an indicator of impulsivity, the increased DD rate is also seen as a behavior indicator of substance addiction (de Wit, Flory, Acheson, McCloskey, & Manuck, 2007; Rung & Madden, 2018). In fact, increased DD rate is highly associated with many maladaptive behaviors such as smoking (MacKillop et al., 2011), alcohol addiction (Bobova, Finn, Rickert, & Lucas, 2009), and gambling problems (Reynolds, 2006). It is also a transdiagnostic process in psychiatric disorders, a meta-analysis demonstrated that increased DD has been observed in psychiatric disorders including major depression disorder, schizophrenia, bipolar disorder and eating disorders (Amlung et al., 2019). Given DD is a relatively stable characteristic of individuals and its association with unhealthy behaviors and psychiatric disorders, a growing body of studies have examined ways to reduce DD rate and change maladaptive behaviors (Scholten et al., 2019).

Two studies have summarized different types of manipulations or trainings used to

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decrease DD (Rung & Madden, 2018; Scholten et al., 2019) including mindfulness-based interventions (Hendrickson & Rasmussen, 2017; Yao et al., 2017), contingency management (Giles, Robalino, McColl, Sniehotta, & Adams, 2014; Stanger, Budney, & Bickel, 2013), acceptance and commitment therapy (Morrison, Madden, Odum, & Twohig, 2014), visualization training (Parthasarathi, McConnell, Luery, & Kable, 2017), and episodic future thinking (EFT) (Bulley & Gullo, 2017) etc. However, for the majority of these methods, the effect to reduce DD rate was mixed. Of these methods, EFT is a promising manipulation to decrease DD rate (Scholten et al., 2019). EFT has been widely investigated and is considered to be a potentially effective manipulation in clinical settings and may have a long-term effect on DD (Boot, Simons, Stothart, & Stutts, 2013; Stein, Tegge, Turner, & Bickel, 2018).

EFT is the ability to project oneself into the future to imagine and pre-experience the future events (Schacter, Addis, & Buckner, 2007; Schacter, Benoit, & Szpunar, 2017). EFT plays an important role in daily lives and is engaged in adaptive behaviors including far-sighted decision-making, emotion regulation, etc. (Brocas & Carrillo, 2018; Schacter et al., 2017; Schacter & Madore, 2016).

To examine the effect of EFT on DD, participants were asked to imagine future events before making choices (Bulley et al., 2019; Stein et al., 2018). Most studies found that EFT reduced DD in healthy individuals (Scholten et al., 2019) and special populations such as smoker (Chiou & Wu, 2017), obese individuals (Daniel, Stanton, & Epstein, 2013a), and alcohol abuse individuals (Snider, LaConte, & Bickel, 2016). In addition to reduce DD rate, EFT also works on behavioral indicators, such as

reducing demand of cigarettes (Stein et al., 2016), alcohol demand intensity (Bulley & Gullo, 2017), calory intake (Daniel, Stanton, & Epstein, 2013b) and so on.

Generally, EFT is effective in reducing DD. However, there are a few studies failed to find an effect of EFT on DD (Hu et al., 2017; Liu, Feng, Chen, & Li, 2013; Palombo, Keane, & Verfaellie, 2016; Zhang, Peng, Qin, Suo, & Feng, 2018). Liu et al. (2013) and Zhang et al. (2018) found that compared with control condition, negative EFT could not reduce DD rate, and even increased DD rate. Palombo et al. (2016) and Hu et al. (2017) found that EFT reduced DD in healthy participants effectively, but not in amnesic patients. For those studies showing an effect of EFT on DD, the effect size varied a lot, ranging from 0.26 to 1.49 (Hollis-Hansen, O'Donnell, Seidman, Brande, & Epstein, 2019). This might be because there are large variations regarding the study characteristics, including EFT related factors, control task related factors, DD task related factors, and participants related factors.

For EFT related factors, the emotional valence of EFT may be associated with its effect on DD (Liu et al., 2013). Positive EFT reduced DD while neutral and negative EFT had no effect of DD, and even increased the DD rate (Zhang et al., 2018). In addition, the method to elicit EFT was different, widely used paradigms included cue word task (Bulley et al., 2019) and autobiographical interview (Ciaramelli, Sellitto, Tosarelli, & di Pellegrino, 2019) . As for cue word task, participants were given cue words to imagine future events (Bulley et al., 2019). While in autobiographical interview, participants were asked to imagine future events that may happen in a specific time period (this method is referred as the time period task below) (Daniel,

Said, Stanton, & Epstein, 2015). It remains unknown whether the different method to elicit EFT would affect its effect on DD.

When examining the effect of EFT on DD, studies used different control tasks as the comparison condition. For example, some studies used episodic recent thinking as the control task, i.e., participants were asked to recall events happened within the past 24 hours before making choices (Daniel et al., 2015; Daniel, Sawyer, Dong, Bickel, & Epstein, 2016), some studies used other types of control task such as story-telling or imagining routine events (Bulley & Gullo, 2017; Bulley et al., 2019), while some studies did not require participants to image or recall any event, just to complete the DD task directly in the control condition (Sasse, Peters, Buechel, & Brassen, 2015). Whether different contents of the control condition lead to different degrees of DD reduction is not yet known (Scholten et al., 2019).

Furthermore, the DD task used in previous studies varied from study to study. For example, the largest reward ranged from 100 (Hollis-Hansen et al., 2019; O'Donnell, Daniel, & Epstein, 2017; Rung & Madden, 2019) to 2000 (Mok et al., 2020). DD rate decreased in larger magnitude of reward compared to smaller magnitude of reward (Green & Myerson, 2004; Kwan et al., 2012), however, whether the effect of EFT on DD rate varied with the magnitude of reward was less studied (Jia et al., 2020). Besides, there was a great variation of delay time in the DD task, the longest delay of delayed reward ranged from 7 days (Cheng, Shein, & Chiou, 2012) to 25 years (Stein et al., 2017). The delay time may be a potential variable that influence the effect of EFT on DD.

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Another group of factors was related to participants, i.e., age of participants and population of participants (general healthy participants vs. special population such as smokers). EFT significantly reduced DD rate in young adults (Mok et al., 2020). Sasse, Peters, and Brassen (2017) found that imagining a scene interacting with another person did not reduce DD rate in older adults. Mok et al. (2020) suggested that the effect of EFT on DD rate was smaller in older adults than in young adults. In addition, EFT was found to reduce DD in different participant groups including healthy individuals (Scholten et al., 2019) and special populations such as smokers, obese individuals, and cannabis use disorders (Chiou & Wu, 2017; Daniel et al., 2013a; Sofis, Lemley, Lee, & Budney, 2020), whether EFT showed a differential effect on DD in different populations remained unknown. We took these factors as moderators in the meta-analysis.

Overall, there is growing attention on approaches to reduce DD, no study has systematically examined which factors affect the efficiency of EFT on DD. The present study aimed to provide a meta-analysis to examine this issue, we considered four groups of factors, including EFT related factors, control task related factors, DD task related factors, and participants related factors, and examined whether these factors moderate the effect of EFT on DD.

## Method

### Literature search

A literature search in Web of Science, Google scholar and Springer were conducted

with the following keywords: (“delay discounting” OR “temporal discounting” OR "time discount\*" OR "intertemporal choice" OR "inter\* decision making") AND ("future thinking" OR “prospection” OR "episodic future thinking" OR "episodic future thought" OR "imagining the future" OR "episodic simulation" OR "future envisioning"). The literature search was from 1990 to June 11, 2020.

The literature search was restricted to peer-reviewed papers published in English. A total of 1954 potential papers were identified from the literature search and additional 28 papers were identified through reference lists from review articles. After excluding irrelevant articles based on title and abstract and removing duplications, 65 papers remained for further consideration. Next, studies were included if the following criteria were met: a) Full-text articles were available (not conference abstracts); b) They were empirical studies, not reviews, comments, or meta-analyses; c) Studies were not case studies; d) Studies measured how EFT impact DD; e) Studies reported sufficient data to calculate effect sizes. For the studies fulfilling previous criteria but without sufficient data to calculate effect sizes, we contacted the authors to provide additional data. If no further data were provided, the studies were excluded from the final analysis. Finally, 37 papers including 48 contrasts were included in the meta-analysis. The flow of literature screening is shown in Fig. 1.

**INSERT FIG 1 HERE**

Data extraction

For each included paper, the following data were extracted: First, the basic information of a study, including the first author and the year of publication; the sample size and mean age of participants, type of participants (healthy participants, special populations). Second, data for calculating effect sizes of EFT on DD. For between-subject design studies, mean and SD on measures of DD were extracted; if mean and SD were not available, other data that could be used to calculate effect sizes such as t-values and sample sizes were extracted. For within-subject design studies, paired t-values, sample sizes and mean were extracted. Nine studies included more than one experiments or different groups of participants, we calculated a separate effect size for each experiment or contrast for these papers. If several studies had a large overlap of participants, we just included one of these studies. For example, these two studies have large overlap in patients (Palombo, Keane, & Verfaellie, 2015; Palombo et al., 2016), we only include the former paper when calculating effect size in patients. Sofis et al. (2020) included DD for gains and DD for losses, since all other studies were on DD for gains, we just included DD for gains in the present meta-analysis. Third, moderators were recorded for moderator analysis or meta-regression analysis. Moderators were mainly classified to four types. (1) EFT related moderators included: the valence of EFT; the method used to elicit EFT (e.g., participants were given cue words to generate EFT or participants were asked to imagine events that may happen during a specific period)<sup>1</sup>; the context of EFT (e.g., personally relevant EFT or task-related EFT. For

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<sup>1</sup> If participants were asked to imagine future events happen in a specific time period during cue generation, then cue words were extracted from these events, and these cue words were provided for EFT during the DD task, these studies were categorized as the cue word task type (Bromberg, Lobatcheva, & Peters, 2017).

personally relevant EFT, participants were asked to imagine personally relevant future events but not related to rewards regarding the DD task; for task-related EFT, participants were asked to imagine events which were related to the reward such as spending money at the delayed time); the longest delay in EFT was also included as a moderator. (2) Control task related moderators included: the context of control task (e.g., no control task, recalling past event, other types such as story-telling or routine events); the valence of control task; and the longest time distance in the control task. (3) DD task related moderators included: the reward type (e.g., hypothetical or potential real. Hypothetical reward means participants would not receive extra reward no matter what they choose in the DD task; potential real reward means participants may receive some reward based on their choice); the DD task type (e.g., whether the choices were prefixed or the choices varied based on participants' responses<sup>2</sup>); the immediate reward type (whether the immediate smaller reward changed or was fixed); the delayed reward type (whether the delayed larger reward changed or was fixed); the outcome indexes of DD (e.g., area under the curve [AUC], K [including  $k$ -value,  $\log k$  value and  $\ln k$  value], proportion of choosing larger later reward, indifference point); the longest delay in DD task; and the largest amount of reward in the DD task. (4) Participants related moderators included: age of participants, and population (healthy individuals or special populations).

## Data analyses

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<sup>2</sup> One example of the former task is the Monetary Choice Questionnaire (Bulley et al., 2019), an example of the latter task used titration algorithm to calculate the amount of reward in the DD task (Ciaramelli et al., 2019).

The data were analyzed using Comprehensive Meta-Analysis (version 2.0) (<https://www.meta-analysis.com/>); Cohen's  $d$  was used as the index of effect size. We first examined the overall effect size of EFT on DD. We then examined whether the effect of EFT on DD performance was related to the following variables using moderator analyses or meta-regression: 1) The valence of EFT; 2) The method used to elicit EFT; 3) The context type of EFT; 4) The longest delay of EFT; 5) The context type of control task; 6) The valence of control task; 7) The longest time distance of control task; 8) The DD reward type; 9) The type of DD paradigm; 10) The immediate reward type; 11) The delay reward type; 12) The outcome index of DD; 13) The longest delay of DD; 14) The largest amount of money reward of DD; 15) The age of participants; 16) the population of participants.

We reported the heterogeneity of the studies with Q statistic, if the heterogeneity was significant, we adopted the random-effects model to report effect sizes; otherwise, we reported results using the fixed-effects model. The moderator analyses adopted the random-effects model. All significance levels were set at  $p < 0.05$  (Hedges & Vevea, 1998). Publication bias was examined with the fail-safe N analysis, which indicated the number of studies with null results needed to reject the present significant findings.

## Results

### Overall effect size of EFT on DD

The final analysis included 37 studies including 48 contrasts to examine the effect of EFT on DD. Table 1 provides a summary of these studies. The mean effect size

(Cohen's  $d$ ) of EFT in reducing DD was 0.58, the 95% confidence interval was 0.45 to 0.71, suggesting that EFT manipulations can reduce DD with a medium effect size (see Fig. 2). These studies were heterogeneous ( $Q=201.69$ ,  $p<0.001$ ). Publication bias analysis revealed that at least 4054 studies with null results were needed to reject the present results, which is much larger than the number of contrasts included in the analysis ( $N=48$ ), suggesting that publication bias was not likely to explain the significant results.

## INSERT TABLE 1 AND FIG 2 HERE

### Moderator and meta-regression analyses

EFT related moderators

#### *The effect of EFT valence*

Positive EFT reduced DD ( $k=27$ ,  $d=0.78$ ,  $p<0.001$ ), EFT with valence not particularly mentioned reduced DD ( $k=12$ ,  $d=0.44$ ,  $p<0.001$ ), positive or neutral EFT reduced DD ( $k=4$ ,  $d=0.57$ ,  $p=0.010$ ), negative EFT ( $k=4$ ,  $d=-0.05$ ,  $p=0.910$ ) or neutral EFT ( $k=3$ ,  $d=0.41$ ,  $p=0.276$ ) did not reduce DD. Considering the number of studies, we only included studies with positive EFT and EFT with valence not mentioned in the moderator analysis, results indicated that the moderator effect of EFT valence was significant ( $Q=5.80$ ,  $p=0.016$ ), suggesting positive EFT had a larger effect (see Table 2).

## INSERT TABLE 2 HERE

### *The effect of method to elicit EFT*

Both methods to elicit EFT reduced DD: cue word task ( $k=17$ ,  $d=0.36$ ,  $p=0.004$ ), time period task ( $k=27$ ,  $d=0.72$ ,  $p<0.001$ ). Time period task showed larger effect in reducing DD than cue word task. ( $Q=5.86$ ,  $p=0.016$ ) (see Table 2).

### *The effect of context type of EFT*

Both personally relevant EFT ( $k=41$ ,  $d=0.59$ ,  $p<0.001$ ) and task-related EFT ( $k=7$ ,  $d=0.52$ ,  $p=0.004$ ) reduced DD. The two context types of EFT showed similar effect on DD ( $Q=0.25$ ,  $p=0.616$ ) (see Table 2).

### *The effect of longest delay in EFT*

Based on the longest delay, we divided the studies into three groups: no more than 180 days ( $\leq 180$  days), between 180 and 365 days ( $180 < X \leq 365$  days), more than 365 days ( $> 365$  days). Results demonstrated that EFT reduced DD irrespective of the length of delay: longest EFT delay no more than 180 days<sup>3</sup> ( $k=7$ ,  $d=0.75$ ,  $p<0.001$ ), between 180 and 365 days ( $k=17$ ,  $d=0.71$ ,  $p<0.001$ ) and more than 365 days ( $k=12$ ,  $d=0.61$ ,  $p<0.001$ ), there was no significant difference among these groups ( $Q=0.95$ ,  $p=0.623$ ).

### Control task related moderators

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<sup>3</sup> The longest EFT delay was 180 days for all studies in this group.

### *The effect of context type of control task*

EFT showed medium effect sizes with all types of control task (no control task,  $k=18$ ,  $d=0.40$ ,  $p=0.003$ ; past event,  $k=19$ ,  $d=0.67$ ,  $p<0.001$ ; other types such as story-telling and routine event,  $k=15$ ,  $d=0.60$ ,  $p<0.001$ ). There was no significant difference among the three types of control task ( $Q=2.86$ ,  $p=0.239$ ).

### *The effect of control task valence*

EFT reduced DD in studies with either positive control task ( $k=13$ ,  $d=0.75$ ,  $p<0.001$ ) or control task with valence not particularly mentioned ( $k=34$ ,  $d=0.51$ ,  $p<0.001$ ). The valence of control task did not influence the EFT effect on DD ( $Q=3.46$ ,  $p=0.063$ ).

### *The effect of longest time distance of control task*

In 14 contrasts, the control task did not mention time distance, EFT reduced DD in these studies ( $d=0.61$ ,  $p<0.001$ ); in 20 contrasts, the control task mentioned the time distance, EFT reduced DD in these studies ( $d=0.66$ ,  $p<0.001$ ). These two groups of studies did not show a significant difference on EFT effect ( $Q=0.10$ ,  $p=0.758$ ).

For those studies mentioned time distance in the control task, we further divided the time limit of control event into those happened within 24 hours or over 24 hours ( $\leq 24$  hours,  $k=9$ ,  $d=0.55$ ,  $p<0.001$ ;  $> 24$  hours,  $k=11$ ,  $d=0.72$ ,  $p<0.001$ ), these two groups of studies showed similar effect ( $Q=1.42$ ,  $p=0.234$ )<sup>4</sup>.

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<sup>4</sup> In these studies, all studies but one asked participants to recall past events in the control task, while one study (Lin & Epstein, 2014) asked participants to imagine events that may happen in the next 24 hours in the control

## DD task related moderators

### *The effect of DD reward type*

When the reward was hypothetical, EFT reduced DD ( $k=36, d=0.68, p<0.001$ ), when the reward was potentially real, EFT did not significantly reduced DD ( $k=12, d=0.26, p=0.087$ ). Moderator analysis revealed that there was significant difference between the two groups, when the reward was hypothetical, EFT had a larger effect ( $Q=6.32, p=0.012$ ).

### *The effect of DD paradigm type*

EFT reduced DD rate when the rewards were fixed in the DD task ( $k=20, d=0.52, p<0.001$ ) and when the rewards varied depend on participants' responses ( $k=28, d=0.62, p<0.001$ ). Results indicated that the moderator effect of DD paradigm was not significant ( $Q=0.68, p=0.411$ ).

### *The effect of immediate reward type*

EFT reduced DD rate when the immediate reward varied ( $k=31, d=0.65, p<0.001$ ) and when the immediate reward was fixed ( $k=17, d=0.46, p<0.001$ ). There was no significant difference between these two conditions ( $Q=1.89, p=0.170$ ).

### *The effect of delayed reward type*

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condition, if we delete this study, the results remained similar ( $Q=1.26, p=0.261, \leq 24$  hours,  $k=8, d=0.55, p<0.001$ ;  $> 24$  hours,  $k=11, d=0.72, p<0.001$ ).

EFT reduced DD rate when the delayed reward varied ( $k=27$ ,  $d=0.42$ ,  $p<0.001$ ) and when the delayed reward was fixed ( $k=21$ ,  $d=0.78$ ,  $p<0.001$ ). There was a significant difference between these two conditions, the EFT effect on DD was larger when delayed reward was fixed ( $Q=8.29$ ,  $p=0.004$ ).

#### *The effect of outcome index of DD task*

Studies used indexes of AUC ( $k=22$ ,  $d=0.73$ ,  $p<0.001$ ) and K (including  $k$ -value, log  $k$  value and  $\ln k$  value) ( $k=19$ ,  $d=0.47$ ,  $p<0.001$ ) showed significant effect of EFT in reducing DD. Other indexes included ratio of choosing larger later reward, ratio of choosing smaller sooner reward, indifference points, studies using these indexes also exhibited a significant effect of EFT in reducing DD ( $k=12$ ,  $d=0.42$ ,  $p<0.001$ ). Considering the great heterogeneity of other indexes, we just compared the indexes of AUC and K, the moderator effect was significant, the EFT effect on DD was larger when AUC was used as the index ( $Q=3.98$ ,  $p=0.046$ ).

#### *The effect of longest delay in DD task*

EFT reduced DD irrespective of the longest delay in the DD task ( $\leq 180$  days,  $k=8$ ,  $d=0.45$ ,  $p=0.033$ ;  $180 < X \leq 365$  days,  $k=22$ ,  $d=0.56$ ,  $p<0.001$ ;  $> 365$  days,  $k=15$ ,  $d=0.79$ ,  $p<0.001$ ), there was no significant difference among these studies ( $Q=4.21$ ,  $p=0.122$ ).

#### *The largest amount of reward in DD task*

EFT reduced DD rate in both small reward ( $<100$ ,  $k=25$ ,  $d=0.55$ ,  $p<0.001$ ) and large

reward ( $\geq 100$ ,  $k=23$ ,  $d=0.68$ ,  $p<0.001$ ) conditions, there was no significant difference between these conditions ( $Q=1.16$ ,  $p=0.281$ ).

## Participants related moderators

### *The effect of age*

EFT reduced DD rate in all age groups ( $\leq 18$  years old ( $k=2$ ,  $d=0.74$ ,  $p=0.004$ ),  $18<X\leq 40$  ( $k=37$ ,  $d=0.56$ ,  $p<0.001$ ),  $40<X\leq 60$  ( $k=3$ ,  $d=0.91$ ,  $p<0.001$ ),  $>60$  ( $k=6$ ,  $d=0.40$ ,  $p=0.002$ )). Results indicated that the moderator effect was not significant ( $Q=4.21$ ,  $p=0.240$ ). However, the numbers of studies for children or adolescents ( $\leq 18$  years old) ( $N=2$ ) and participants between 40 and 60 years old ( $40<X\leq 60$ ,  $k=3$ ) were limited. We further divided studies into two groups: no more than 40 years old ( $k=39$ ,  $d=0.58$ ,  $p<0.001$ ) and over 40 ( $k=9$ ,  $d=0.60$ ,  $p<0.001$ ), the moderator effect was still not significant ( $Q=0.02$ ,  $p=0.898$ ). Furthermore, meta-regression analysis revealed that age was not significantly related to EFT effect ( $Z=-0.69$ ,  $p=0.488$ ).

### *The population of participants*

EFT reduced DD rate in both healthy individuals ( $k=40$ ,  $d=0.59$ ,  $p<0.001$ ) and special populations ( $k=8$ ,  $d=0.50$ ,  $p<0.001$ ), there was no significant difference between these studies ( $Q=0.35$ ,  $p=0.355$ ).

## Discussion

In the present meta-analysis, 37 studies including 48 contrasts were included to examine the effect of EFT in reducing DD. Results indicated that EFT reduced DD with medium effect size (Cohen's  $d=0.58$ ) and publication bias was not likely to account for this significant finding. Moderator analyses revealed that the EFT valence, the method used to elicit EFT, the reward type, the delayed reward money type and the outcome index of DD was significantly correlated with the efficiency of EFT in reducing DD.

### Overall effect of EFT in reducing DD

The present meta-analysis revealed that EFT significantly reduced DD. There may be several potential mechanisms.

First, according to the Construal Level Theory (Trope & Liberman, 2003), the concreteness of thought were related to perceived time distance (Lempert & Phelps, 2016). The future events are more abstract and with more essential features under high construal level, while the present events are more concrete and detailed under low construal level. EFT may provide a chance for participants to transfer their representation of future events from high construal level to low construal level by imaging future event with concrete details. Through imagining and representing rich details, it may make the future outcomes more attractive and increase the possibility to choose the delayed option (Bulley et al., 2019). Previous studies also provided evidence that the degree of reduced DD by EFT was significantly related to the concreteness and vividness of EFT, the more details and vividness of imagination, the greater reduction

in DD (Benoit, Gilbert, & Burgess, 2011; Kim, Schnall, & White, 2013; Peters & Büchel, 2010; Zhang et al., 2018).

Second, EFT makes people pre-experience future events and generate anticipatory feelings (Suddendorf & Moore, 2011). According to Bulley, Henry, and Suddendorf (2016), the value and perceived likelihood of future rewards are two synergistic feedback factors for decision making, EFT influences these two factors to moderate the DD choices. For example, anticipation of future events may expand the temporal window which may increase tolerance for delayed rewards, people would prefer to choose the larger reward which brings more good feelings (Snider et al., 2016). The vivid EFT may let people anticipate more of the future reward and the anticipation may add weight to the value of delayed reward which provide a stronger motivation for goal pursuit (Bulley et al., 2019; Miloyan, Bulley, & Suddendorf, 2016; Renner, Murphy, Ji, Manly, & Holmes, 2019). Besides, the EFT may increase the perceived likelihood of future rewards which may increase the probability of choosing the delayed option (Bulley et al., 2016).

Third, EFT may reduce DD through increasing self-control. Self-control is considered as an essential capacity in DD (Adele, 2013; Herrmann, Misch, Hernandez-Lloreda, & Tomasello, 2015). According to the self-control model, individuals would reconsider the delayed reward in decision-making phrase through the self-control system. For example, even though the immediate option has higher subjective value than the delayed option, individuals may still choose the latter option which has greater benefit, these processes were regulated by lateral prefrontal cortex which related to self-

control function (Figner et al., 2010). The impulsiveness reflects decreased or impairments in self-control (Tangney, Baumeister, & Boone, 2004). EFT may strengthen self-regulation to revalue the delayed reward and inhibit the impulsive behavior (Baumeister, 2014; Boyer, 2008; Bulley & Gullo, 2017).

Regarding the underlying neural mechanisms, Peters and Büchel (2011) summarized previous studies and suggested that DD was related to three neurocognitive systems, i.e., the valuation network, the cognitive control network, and the medial temporal lobe (imagery/prospection) network. EFT was related to brain regions including ventromedial prefrontal cortex (vmPFC), medial temporal lobe, and amygdala (Schacter et al., 2017). During EFT, the activation and connectivity between these regions are strengthened, which would reduce DD rate (Peters & Büchel, 2011). Specifically, one of the key regions is vmPFC, it is not only related to EFT, but also involved in valuation judgement and cognitive control (Hare, Camerer, & Rangel, 2009; Peters & Buechel, 2009). The vmPFC regulated connections among the three networks, specifically, vmPFC was involved in representation of future events during imagination, then vmPFC regulated the judgement of subjective value for delayed reward, in addition, vmPFC inspired the self-control ability and self-regulation to help individuals choose delayed option (Benoit et al., 2011; Jenkins & Hsu, 2017). Furthermore, Sasse et al. (2017) found that the functional connectivity between hippocampus and anterior cingulate cortex (ACC) was positively correlated with control capacity, while these two regions were activated during EFT (Schacter et al., 2017), these results further supported that EFT may regulate cognitive control to inhibit the impulsive choices

(Sasse et al., 2017).

Taken together, several hypotheses have been proposed on the underlying mechanisms of the effect of EFT on DD, these mechanisms may work together to reduce DD.

### **EFT related moderators**

According to the present results, the majority of studies found EFT significantly reduced DD. However, several factors moderated this effect. One main factor is the valence of EFT. Positive EFT significantly reduced DD with a medium effect size (Bulley et al., 2019; Calluso, Tosoni, Cannito, & Committed, 2019; Zhang et al., 2018). Baumeister and Masicampo (2010) indicated that the EFT emotion may act as a “motivational brake”, which means that the positive EFT helped individuals to counteract the impulsiveness of choosing the immediate option. The present results showed that negative or neutral EFT could not reduce DD rate. Though previous studies showed inconsistent findings on negative EFT and the number of studies involving negative EFT was small (Bulley et al., 2019; Calluso et al., 2019; Liu et al., 2013; Zhang et al., 2018), the results of moderator analysis (positive EFT reduced DD to a greater degree than EFT with valence not mentioned) provided indirect evidence that negative EFT would have a smaller effect in reducing DD rate, since in these studies did not mention the valence of EFT, participants may imagine neutral or negative future events, and these types of EFT showed a significantly smaller effect in reducing DD. These results suggested that positive EFT is essential in reducing DD.

As to the method to elicit EFT, cue word task and time period task were most commonly used. Our results revealed that the time period task showed greater effect in DD reduction than the cue word task. One possible reason is that in studies adopting cue word task to elicit EFT, several studies used negative or neutral cue words to elicit EFT, thus negative or neutral EFT may be anticipated, while in studies adopting time period task, mostly studies require participants to imagine positive events in the given time period. As mentioned before, the valence of EFT was an essential factor moderating the efficiency of EFT in reducing DD. However, the present meta-analysis could not examine the interaction between EFT valence and method to elicit EFT, future studies are needed to compare these two methods directly.

As to the context type of EFT, both personally related and task related EFT reduced DD to a similar degree. For the time distance of EFT, it was not related to the efficiency of EFT in reducing DD. One potential reason is that thinking about future events that might happen in a few months could broaden the time horizon to a similar degree to those in a few years, thus the effect on DD might be the same no matter how distant into the future they imagine. From the neural perspective, it might be whether participants imagine personal relevant events or task related events, whether they imagine relatively distant future or relatively recent future, they activated similar brain regions such as vmPFC and hippocampus (D'Argembeau, Xue, Lu, Van der Linden, & Bechara, 2008) and reduced DD to a similar degree (Benoit et al., 2011; Palombo et al., 2015).

### **Control task related moderators**

The present meta-analysis demonstrated that the characteristics of control task was not related to the efficiency of episodic recent thinking in reducing DD. There are several types of control task including no control task, episodic recent thinking, and other tasks such as story-telling or describing routine events (Calluso et al., 2019; Cheng et al., 2012; Hollis-Hansen et al., 2019). Compared with all types of control task, EFT showed similar and significant effect on DD. As for story-telling task, it controls individual's verbal ability and scene construction (Bulley & Gullo, 2017); episodic recent thinking requires individuals to vividly describe recent events, this task controls the scene construction and self-relevance (Hollis-Hansen et al., 2019). EFT reduced DD when taking these types of task as the control condition, suggesting that the EFT effect on DD was not confounded by context of control task (Bulley et al., 2016).

As to the events recalled in the control task, the retrospective time period ranged from the past 24 hours to 3 years. The present results demonstrated that the time distance of the control task was not associated with the EFT effect (O'Donnell, Hollis-Hansen, & Epstein, 2018). Moreover, the valence of the control task did not influence the EFT effect either, it suggests that only the emotional valence of EFT is critical in reducing DD. Although we did not find any significant effect on moderators relating to control task, the standardization of control task is necessary when examining the efficiency of EFT on DD (Scholten et al., 2019).

### **DD related moderators**

DD has been investigated with various tasks (Mok et al., 2020; Scholten et al., 2019). The present study examined several characteristics of the DD task. We found that EFT reduced DD to a larger degree in studies using hypothetical money reward than studies using potential real money reward, which is inconsistent with previous studies which suggesting both hypothetical and potential real rewards yielded similar effect of EFT in reducing DD (Lawyer, Schoepflin, Green, & Jenks, 2011; Madden, Begotka, Raiff, & Kastern, 2003; Madden et al., 2004). One possible reason is that when using potential real reward, the amount of reward was relatively small, while using hypothetical reward, the amount of reward can be larger, although the amount of reward did not show a significant effect (discussed below), there might be an interaction that could not be analyzed in this meta-analysis. Another factor needs to be mentioned is the number of the two types of studies has a large difference, almost 75% studies used hypothetical reward, future studies need to focus more on potential real money reward to compare the effect of EFT on DD.

The DD paradigm can be divided into two types, the fixed task in which the amount of reward is fixed, not influenced by participants' choices, and the varied task in which the amount of reward changed according to participants' responses, both paradigms showed similar significant reduction in DD by EFT (Bromberg et al., 2017; Jia et al., 2020). In addition, whether the immediate reward was fixed or changed showed similar degree of DD reduction by EFT. These results suggested that the effect of EFT was stable. We found that fixed delayed reward showed a larger degree of EFT reduction than variable delayed reward. One possible reason is that individuals may be more

sensitive to fixed delayed rewards than to variable rewards. Although there was a difference between the type of the delayed rewards, EFT reduced DD in a medium to large effect size with both fixed and variable delayed rewards.

AUC and K related indexes are two main types of indexes of DD, the present results indicated that EFT reduced delay discounting using both AUC and K as indexes, consistent with Bromberg et al. (2017) and Hu et al. (2017). We also found that EFT had a larger effect on AUC than K related indexes, however, there is no study directly comparing the effect of EFT in reducing DD with different indexes (Hamilton et al., 2015). Further studies are needed to examine the meaning and difference between AUC and K related indexes.

Whether the amount of reward affect the effect of EFT on DD or not showed inconsistent findings. Some studies suggested that the amount of reward was not associated with the EFT effect (Jia et al., 2020; Kwan et al., 2012). However, Mok et al. (2020) found that the EFT effect was smaller when the amount of reward was large compared to small reward. The present results demonstrated that the effect of EFT in reducing DD was similar in small and large reward. One possible reason is related to the division of large and small amount, some studies suggest that over 2000 can be considered as large reward (Kuo, Lee, & Chiou, 2016; Mok et al., 2020), but the present study classified by 100 due to the limited number of studies using over 2000 as reward. Another factor should be considered is that studies conducted in different countries used different currency, it might be necessary to take exchange rate into consideration in the future when dividing large and small reward.

## **Participants related moderators**

Very few studies have compared the effect of EFT in reducing DD across age groups. Sasse et al. (2017) indicated that EFT did not reduce DD in older groups, while Mok et al. (2020) indicated that the effect of EFT also reduced DD in older groups. The present results demonstrated that the effect of EFT in reducing DD was evident for all age groups including adolescent, young and older adults. Moreover, we found that EFT reduced DD in both healthy individuals and special populations, consistent to previous studies which suggested the EFT effect is widespread, involving different populations and ranging from financial reward to maladaptive behaviors (Dassen, Jansen, Nederkoorn, & Houben, 2016).

## **Limitations and implications**

There are several limitations in the present study. First, even though we reviewed different models and potential mechanisms, the underlying mechanisms still need to be examined. Second, some studies considered other outcomes such as cigarette smoking, energy intake and alcohol demanding (Daniel et al., 2015; Stein et al., 2016), but the present study did not analyze these outcomes due to the limited number of studies. Third, studies have shown that episodic past thinking could also reduce DD (Lempert, Speer, Delgado, & Phelps, 2017), however, the number of studies were not enough to be included as a subgroup analysis. Further studies need to examine whether this effect is stable and whether there are differential effect of EFT and episodic past thinking in

reducing DD. Fourth, most studies examined the effect of EFT on DD for gains, whether EFT could reduce DD for losses needs further investigation. Fifth, for several moderator analysis, the number of studies included in each subgroup were imbalanced, further studies are needed in several subgroups. For example, more studies are needed in the adolescent group, since adolescents are impulsive and showed large DD rate (Steinberg, 2008; White et al., 2014); more studies are needed in clinical patients, since increased DD rate is a transdiagnostic process in psychiatric disorders (Amlung et al., 2019).

Notwithstanding the above limitations, there are some implications of this study. First, EFT is an effective manipulation to reduce DD. One future direction is to apply this method in clinical populations with impulsive behaviors. Second, given that positive EFT had larger effect in reducing DD, when applying EFT, requiring participants to imagine future positive events is an optimal option.

## Reference

- Adele, D. (2013). Executive Functions. *64*(1), 135-168. doi:10.1146/annurev-psych-113011-143750
- Amlung, M., Marsden, E., Holshausen, K., Morris, V., Patel, H., Vedelago, L., . . . McCabe, R. E. (2019). Delay Discounting as a Transdiagnostic Process in Psychiatric Disorders: A Meta-analysis. *JAMA Psychiatry*, *76*(11), 1176-1186. doi:10.1001/jamapsychiatry.2019.2102
- Baumeister, R. F. (2014). Self-regulation, ego depletion, and inhibition. *Neuropsychologia*, *65*, 313-319. doi:10.1016/j.neuropsychologia.2014.08.012
- Baumeister, R. F., & Masicampo, E. J. (2010). Conscious Thought Is for Facilitating Social and Cultural Interactions: How Mental Simulations Serve the Animal-Culture Interface. *Psychological Review*, *117*(3), 945-971. doi:10.1037/a0019393

- Benoit, R. G., Gilbert, S. J., & Burgess, P. W. (2011). A Neural Mechanism Mediating the Impact of Episodic Prospection on Farsighted Decisions. *Journal of Neuroscience*, *31*(18), 6771-6779. doi:10.1523/jneurosci.6559-10.2011
- Bobova, L., Finn, P. R., Rickert, M. E., & Lucas, J. (2009). Disinhibitory Psychopathology and Delay Discounting in Alcohol Dependence: Personality and Cognitive Correlates. *Experimental and clinical psychopharmacology*, *17*(1), 51-61. doi:10.1037/a0014503
- Boot, W. R., Simons, D. J., Stothart, C., & Stutts, C. (2013). The Pervasive Problem With Placebos in Psychology: Why Active Control Groups Are Not Sufficient to Rule Out Placebo Effects. *Perspectives on Psychological Science*, *8*(4), 445-454. doi:10.1177/1745691613491271
- Boyer, P. (2008). Evolutionary economics of mental time travel? *Trends in Cognitive Sciences*, *12*(6), 219-224. doi:org/10.1016/j.tics.2008.03.003
- Brocas, I., & Carrillo, J. D. (2018). A Neuroeconomic Theory of Mental Time Travel. *Frontiers in Neuroscience*, *12*. doi:10.3389/fnins.2018.00658
- Bromberg, U., Lobatcheva, M., & Peters, J. (2017). Episodic future thinking reduces temporal discounting in healthy adolescents. *PloS One*, *12*(11). doi:10.1371/journal.pone.0188079
- Bulley, A., & Gullo, M. J. (2017). The influence of episodic foresight on delay discounting and demand for alcohol. *Addictive Behaviors*, *66*, 1-6. doi:org/10.1016/j.addbeh.2016.11.003
- Bulley, A., Henry, J. D., & Suddendorf, T. (2016). Prospection and the Present Moment: The Role of Episodic Foresight in Intertemporal Choices Between Immediate and Delayed Rewards. *Review of General Psychology*, *20*(1), 29-47. doi:10.1037/gpr0000061
- Bulley, A., Miloyan, B., Pepper, G. V., Gullo, M. J., Henry, J. D., & Suddendorf, T. (2019). Cuing both positive and negative episodic foresight reduces delay discounting but does not affect risk-taking. *Quarterly Journal of Experimental Psychology*, *72*(8), 1998-2017. doi:10.1177/1747021818819777
- Calluso, C., Tosoni, A., Cannito, L., & Committed, G. (2019). Concreteness and emotional valence of episodic future thinking (EFT) independently affect the dynamics of intertemporal decisions. *PloS One*, *14*(5). doi:10.1371/journal.pone.0217224
- Cheng, Y. Y., Shein, P. P., & Chiou, W. B. (2012). Escaping the impulse to immediate gratification: the prospect concept promotes a future-oriented mindset, prompting an inclination towards delayed gratification. *British Journal of Psychology*, *103*(1), 129-141. doi:10.1111/j.2044-8295.2011.02067.x
- Chiou, W. B., & Wu, W. H. (2017). Episodic Future Thinking Involving the Nonsmoking Self Can Induce Lower Discounting and Cigarette Consumption. *Journal of Studies on Alcohol and Drugs*, *78*(1), 106-112. doi:10.15288/jsad.2017.78.106.
- Ciaramelli, E., Sellitto, M., Tosarelli, G., & di Pellegrino, G. (2019). Imagining Events Alternative to the Present Can Attenuate Delay Discounting. *Frontiers in Behavioral Neuroscience*, *13*. doi:10.3389/fnbeh.2019.00269
- D'Argembeau, A., Xue, G., Lu, Z. L., Van der Linden, M., & Bechara, A. (2008). Neural correlates of envisioning emotional events in the near and far future. *NeuroImage*, *40*(1), 398-407. doi:org/10.1016/j.neuroimage.2007.11.025
- Daniel, T. O., Said, M., Stanton, C. M., & Epstein, L. H. (2015). Episodic future thinking reduces delay discounting and energy intake in children. *Eating Behaviors*, *18*, 20-24. doi:org/10.1016/j.eatbeh.2015.03.006
- Daniel, T. O., Sawyer, A., Dong, Y. L., Bickel, W. K., & Epstein, L. H. (2016). Remembering Versus

- Imagining: When Does Episodic Retrospection and Episodic Propection Aid Decision Making? *Journal of Applied Research in Memory and Cognition*, 5(3), 352-358. doi:org/10.1016/j.jarmac.2016.06.005
- Daniel, T. O., Stanton, C. M., & Epstein, L. H. (2013a). The future is now: comparing the effect of episodic future thinking on impulsivity in lean and obese individuals. *Appetite*, 71, 120-125. doi:10.1016/j.appet.2013.07.010
- Daniel, T. O., Stanton, C. M., & Epstein, L. H. (2013b). The future is now: reducing impulsivity and energy intake using episodic future thinking. *Psychological science*, 24(11), 2339-2342. doi:10.1177/0956797613488780
- Dassen, F. C. M., Jansen, A., Nederkoorn, C., & Houben, K. (2016). Focus on the future: Episodic future thinking reduces discount rate and snacking. *Appetite*, 96, 327-332. doi:org/10.1016/j.appet.2015.09.032
- de Wit, H., Flory, J. D., Acheson, A., McCloskey, M., & Manuck, S. B. (2007). IQ and nonplanning impulsivity are independently associated with delay discounting in middle-aged adults. *Personality and Individual Differences*, 42(1), 111-121. doi:10.1016/j.paid.2006.06.026
- Figner, B., Knoch, D., Johnson, E. J., Krosch, A. R., Lisanby, S. H., Fehr, E., & Weber, E. U. (2010). Lateral prefrontal cortex and self-control in intertemporal choice. *Nature Neuroscience*, 13(5), 538-539. doi:10.1038/nn.2516
- Frederick, S., Loewenstein, G., & O'Donoghue, T. (2002). Time discounting and time preference: A critical review. *Journal of Economic Literature*, 40(2), 351-401. doi:10.1257/002205102320161311
- Giles, E. L., Robalino, S., McColl, E., Sniehotta, F. F., & Adams, J. (2014). The Effectiveness of Financial Incentives for Health Behaviour Change: Systematic Review and Meta-Analysis. *PloS One*, 9(3). doi:10.1371/journal.pone.0090347
- Green, L., & Myerson, J. (2004). A discounting framework for choice with delayed and probabilistic rewards. *Psychological bulletin*, 130(5), 769-792. doi:10.1037/0033-2909.130.5.769
- Hamilton, K. R., Mitchell, M. R., Wing, V. C., Balodis, I. M., Bickel, W. K., Fillmore, M., . . . Moeller, F. G. (2015). Choice Impulsivity: Definitions, Measurement Issues, and Clinical Implications. *Personality Disorders-Theory Research and Treatment*, 6(2), 182-198. doi:10.1037/per0000099
- Hare, T. A., Camerer, C. F., & Rangel, A. (2009). Self-Control in Decision-Making Involves Modulation of the vmPFC Valuation System. *Science*, 324(5927), 646-648. doi:10.1126/science.1168450
- Hedges, L. V., & Vevea, J. L. (1998). Fixed- and random-effects models in meta-analysis. *Psychological Methods*, 3(4), 486-504. doi:10.1037/1082-989x.3.4.486
- Hendrickson, K. L., & Rasmussen, E. B. (2017). Mindful Eating Reduces Impulsive Food Choice in Adolescents and Adults. *Health Psychology*, 36(3), 226-235. doi:10.1037/hea0000440
- Herrmann, E., Misch, A., Hernandez-Lloreda, V., & Tomasello, M. (2015). Uniquely human self-control begins at school age. *Developmental Science*, 18(6), 979-993. doi:10.1111/desc.12272
- Hollis-Hansen, K., O'Donnell, S. E., Seidman, J. S., Brande, S. J., & Epstein, L. H. (2019). Improvements in episodic future thinking methodology: Establishing a standardized episodic thinking control. *PloS One*, 14(3). doi:10.1371/journal.pone.0214397
- Hu, X. C., Kleinschmidt, H., Martin, J. A., Han, Y., Thelen, M., Meibberth, D., . . . Weber, B. (2017). A

- Reduction in Delay Discounting by Using Episodic Future Imagination and the Association with Episodic Memory Capacity. *10*(663). doi:10.3389/fnhum.2016.00663
- Jenkins, A. C., & Hsu, M. (2017). Dissociable Contributions of Imagination and Willpower to the Malleability of Human Patience. *Psychological science*, *28*(7), 894-906. doi:10.1177/0956797617698133
- Jia, L. X., Liu, Z., Cui, J. F., Ding, Q. Y., Ye, J. Y., Liu, L. L., . . . Wang, Y. (2020). Future thinking is related to lower delay discounting than recent thinking, regardless of the magnitude of the reward, in individuals with schizotypy. *Australian Psychologist*. doi:org/10.1111/ap.12460
- Kim, H., Schnall, S., & White, M. P. (2013). Similar Psychological Distance Reduces Temporal Discounting. *Personality and Social Psychology Bulletin*, *39*(8), 1005-1016. doi:10.1177/0146167213488214
- Kuo, H. C., Lee, C. C., & Chiou, W. B. (2016). The Power of the Virtual Ideal Self in Weight Control: Weight-Reduced Avatars Can Enhance the Tendency to Delay Gratification and Regulate Dietary Practices. *Cyberpsychology Behavior and Social Networking*, *19*(2), 80-85. doi:10.1089/cyber.2015.0203
- Kwan, D., Craver, C. F., Green, L., Myerson, J., Boyer, P., & Rosenbaum, R. S. (2012). Future decision-making without episodic mental time travel. *Hippocampus*, *22*(6), 1215-1219. doi:10.1002/hipo.20981
- Lawyer, S. R., Schoepflin, F., Green, R., & Jenks, C. (2011). Discounting of hypothetical and potentially real outcomes in nicotine-dependent and nondependent samples. *Experimental and clinical psychopharmacology*, *19*(4), 263-274. doi:10.1037/a0024141
- Lempert, K. M., & Phelps, E. A. (2016). The Malleability of Intertemporal Choice. *Trends in Cognitive Sciences*, *20*(1), 64-74. doi:10.1016/j.tics.2015.09.005
- Lempert, K. M., Speer, M. E., Delgado, M. R., & Phelps, E. A. (2017). Positive autobiographical memory retrieval reduces temporal discounting. *Social Cognitive and Affective Neuroscience*, *12*(10), 1584-1593. doi:10.1093/scan/nsx086
- Lin, H., & Epstein, L. H. (2014). Living in the Moment: Effects of Time Perspective and Emotional Valence of Episodic Thinking on Delay Discounting. *Behavioral Neuroscience*, *128*(1), 12-19. doi:10.1037/a0035705
- Liu, L., Feng, T. Y., Chen, J., & Li, H. (2013). The Value of Emotion: How Does Episodic Prospection Modulate Delay Discounting? *PloS One*, *8*(11). doi:10.1371/journal.pone.0081717
- Logue, A. W. (1988). Research on self-control: An integrating framework. *Behavioral and Brain Sciences*, *11*(4), 665-678. doi:10.1017/s0140525x00053978
- MacKillop, J., Amlung, M. T., Few, L. R., Ray, L. A., Sweet, L. H., & Munafo, M. R. (2011). Delayed reward discounting and addictive behavior: a meta-analysis. *Psychopharmacology*, *216*(3), 305-321. doi:10.1007/s00213-011-2229-0
- Madden, G. J., Begotka, A. M., Raiff, B. R., & Kastern, L. L. (2003). Delay discounting of real and hypothetical rewards. *Experimental and clinical psychopharmacology*, *11*(2), 139-145. doi:10.1037/1064-1297.11.2.139
- Madden, G. J., Raiff, B. R., Lagorio, C. H., Begotka, A. M., Mueller, A. M., Hehli, D. J., & Wegener, A. A. (2004). Delay discounting of potentially real and hypothetical rewards: II. Between- and within-subject comparisons. *Experimental and clinical psychopharmacology*, *12*(4), 251-261. doi:10.1037/1064-1297.12.4.251

- Miloyan, B., Bulley, A., & Suddendorf, T. (2016). Episodic foresight and anxiety: Proximate and ultimate perspectives. *British Journal of Clinical Psychology*, 55(1), 4-22. doi:10.1111/bjc.12080
- Mok, J. N. Y., Kwan, D., Green, L., Myerson, J., Craver, C. F., & Rosenbaum, R. S. (2020). Is it time? Episodic imagining and the discounting of delayed and probabilistic rewards in young and older adults. *Cognition*, 199, 104222. doi:org/10.1016/j.cognition.2020.104222
- Morrison, K. L., Madden, G. J., Odum, A. L., & Twohig, M. P. (2014). Altering Impulsive Decision Making With an Acceptance-Based Procedure. *Behavior Therapy*, 45(5), 630-639. doi:10.1016/j.beth.2014.01.001
- O'Donnell, Daniel, T. O., & Epstein, L. H. (2017). Does goal relevant episodic future thinking amplify the effect on delay discounting? *Consciousness and Cognition*, 51, 10-16. doi:10.1016/j.concog.2017.02.014
- O'Donnell, Hollis-Hansen, K., & Epstein, L. H. (2018). Mix and Match: An Investigation into Whether Episodic Future Thinking Cues Need to Match Discounting Delays in Order to Be Effective. *Behavioral sciences (Basel, Switzerland)*, 9(1). doi:10.3390/bs9010001
- Palombo, D. J., Keane, M. M., & Verfaellie, M. (2015). The Medial Temporal Lobes Are Critical for Reward-Based Decision Making Under Conditions That Promote Episodic Future Thinking. *Hippocampus*, 25(3), 345-353. doi:10.1002/hipo.22376
- Palombo, D. J., Keane, M. M., & Verfaellie, M. (2016). Using future thinking to reduce temporal discounting: Under what circumstances are the medial temporal lobes critical? *Neuropsychologia*, 89, 437-444. doi:org/10.1016/j.neuropsychologia.2016.07.002
- Parthasarathi, T., McConnell, M. H., Luery, J., & Kable, J. W. (2017). The Vivid Present: Visualization Abilities Are Associated with Steep Discounting of Future Rewards. *Frontiers in Psychology*, 8. doi:10.3389/fpsyg.2017.00289
- Peters, J., & Büchel, C. (2010). Episodic Future Thinking Reduces Reward Delay Discounting through an Enhancement of Prefrontal-Mediotemporal Interactions. *Neuron*, 66(1), 138-148. doi:org/10.1016/j.neuron.2010.03.026
- Peters, J., & Büchel, C. (2011). The neural mechanisms of inter-temporal decision-making: understanding variability. *Trends in Cognitive Sciences*, 15(5), 227-239. doi:10.1016/j.tics.2011.03.002
- Peters, J., & Buechel, C. (2009). Overlapping and Distinct Neural Systems Code for Subjective Value during Intertemporal and Risky Decision Making. *Journal of Neuroscience*, 29(50), 15727-15734. doi:10.1523/jneurosci.3489-09.2009
- Renner, F., Murphy, F. C., Ji, J. L., Manly, T., & Holmes, E. A. (2019). Mental imagery as a "motivational amplifier" to promote activities. *Behaviour Research and Therapy*, 114, 51-59. doi:org/10.1016/j.brat.2019.02.002
- Reynolds, B. (2006). A review of delay-discounting research with humans: relations to drug use and gambling. *Behavioural Pharmacology*, 17(8), 651-667. doi:10.1097/FBP.0b013e3280115f99
- Rung, J. M., & Madden, G. J. (2018). Experimental Reductions of Delay Discounting and Impulsive Choice: A Systematic Review and Meta-Analysis. *Journal of Experimental Psychology-General*, 147(9), 1349-1381. doi:10.1037/xge0000462
- Rung, J. M., & Madden, G. J. (2019). Demand Characteristics in Episodic Future Thinking II: The Role of Cues and Cue Content in Changing Delay Discounting. *Experimental and clinical*

- psychopharmacology*, 27(5), 482-495. doi:10.1037/pha0000260
- Sasse, L. K., Peters, J., & Brassen, S. (2017). Cognitive Control Modulates Effects of Episodic Simulation on Delay Discounting in Aging. *Frontiers in Aging Neuroscience*, 9. doi:10.3389/fnagi.2017.00058
- Sasse, L. K., Peters, J., Buechel, C., & Brassen, S. (2015). Effects of Prospective Thinking on Intertemporal Choice: The Role of Familiarity. *Human Brain Mapping*, 36(10), 4210-4221. doi:10.1002/hbm.22912
- Schacter, D. L., Addis, D. R., & Buckner, R. L. (2007). Remembering the past to imagine the future: the prospective brain. *Nature Reviews Neuroscience*, 8(9), 657-661. doi:10.1038/nrn2213
- Schacter, D. L., Benoit, R. G., & Szpunar, K. K. (2017). Episodic future thinking: mechanisms and functions. *Current Opinion in Behavioral Sciences*, 17, 41-50. doi:10.1016/j.cobeha.2017.06.002
- Schacter, D. L., & Madore, K. P. (2016). Remembering the past and imagining the future: Identifying and enhancing the contribution of episodic memory. *Memory Studies*, 9(3), 245-255. doi:10.1177/1750698016645230
- Scholten, H., Scheres, A., de Water, E., Graf, U., Granic, I., & Luijten, M. (2019). Behavioral trainings and manipulations to reduce delay discounting: A systematic review. *Psychonomic Bulletin & Review*, 26(6), 1803-1849. doi:10.3758/s13423-019-01629-2
- Sellitto, M., Ciaramelli, E., & di Pellegrino, G. (2011). The neurobiology of intertemporal choice: insight from imaging and lesion studies. *Reviews in the Neurosciences*, 22(5), 565-574. doi:10.1515/rns.2011.046
- Snider, S. E., LaConte, S. M., & Bickel, W. K. (2016). Episodic Future Thinking: Expansion of the Temporal Window in Individuals with Alcohol Dependence. *Alcoholism, Clinical and Experimental Research*, 40(7), 1558-1566. doi:10.1111/acer.13112
- Sofis, M. J., Lemley, S. M., Lee, D. C., & Budney, A. J. (2020). A web-based episodic specificity and future thinking session modulates delay discounting in cannabis users. *Psychology of addictive behaviors : journal of the Society of Psychologists in Addictive Behaviors*. doi:10.1037/adb0000557
- Stanger, C., Budney, A. J., & Bickel, W. K. (2013). A Developmental Perspective on Neuroeconomic Mechanisms of Contingency Management. *Psychology of Addictive Behaviors*, 27(2), 403-415. doi:10.1037/a0028748
- Stein, J. S., Sze, Y. Y., Athamneh, L., Koffarnus, M. N., Epstein, L. H., & Bickel, W. K. (2017). Think fast: rapid assessment of the effects of episodic future thinking on delay discounting in overweight/obese participants. *Journal of Behavioral Medicine*, 40(5), 832-838. doi:10.1007/s10865-017-9857-8
- Stein, J. S., Tegge, A. N., Turner, J. K., & Bickel, W. K. (2018). Episodic future thinking reduces delay discounting and cigarette demand: an investigation of the good-subject effect. *Journal of Behavioral Medicine*, 41(2), 269-276. doi:10.1007/s10865-017-9908-1
- Stein, J. S., Wilson, A. G., Koffarnus, M. N., Daniel, T. O., Epstein, L. H., & Bickel, W. K. (2016). Unstuck in time: episodic future thinking reduces delay discounting and cigarette smoking. *Psychopharmacology*, 233(21-22), 3771-3778. doi:10.1007/s00213-016-4410-y
- Steinberg, L. (2008). A social neuroscience perspective on adolescent risk-taking. *Developmental Review*, 28(1), 78-106. doi:doi.org/10.1016/j.dr.2007.08.002
- Suddendorf, T., & Moore, C. (2011). Introduction to the special issue: The development of episodic

foresight. *Cognitive Development*, 26(4), 295-298. doi:10.1016/j.cogdev.2011.09.001

Tangney, J. P., Baumeister, R. F., & Boone, A. L. (2004). High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *Journal of Personality*, 72(2), 271-324. doi:10.1111/j.0022-3506.2004.00263.x

Trope, Y., & Liberman, N. (2003). Temporal construal. *Psychological Review*, 110(3), 403-421. doi:10.1037/0033-295x.110.3.403

White, S. F., Clanton, R., Brislin, S. J., Meffert, H., Hwang, S., Sinclair, S., & Blair, R. J. R. (2014). Reward: empirical contribution. Temporal discounting and conduct disorder in adolescents. *Journal of personality disorders*, 28(1), 5-18. doi:10.1521/pedi.2014.28.1.5

Yao, Y. W., Chen, P. R., Li, C. S. R., Hare, T. A., Li, S., Zhang, J. T., . . . Fang, X. Y. (2017). Combined reality therapy and mindfulness meditation decrease intertemporal decisional impulsivity in young adults with Internet gaming disorder. *Computers in Human Behavior*, 68, 210-216. doi:10.1016/j.chb.2016.11.038

Zhang, S. M., Peng, J., Qin, L. L., Suo, T., & Feng, T. Y. (2018). Prospective emotion enables episodic prospection to shift time preference. *British Journal of Psychology*, 109(3), 487-499. doi:10.1111/bjop.12284

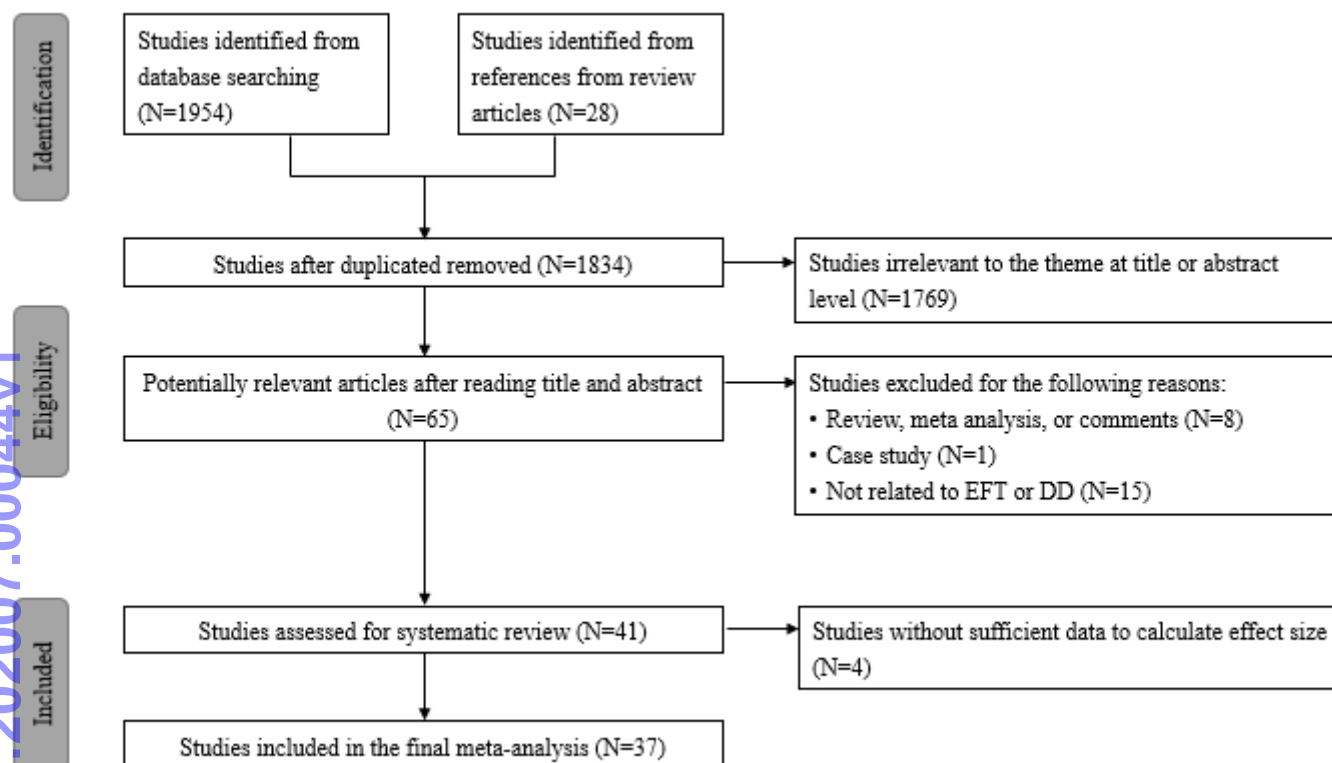


Fig. 1 Flow diagram of article selection.

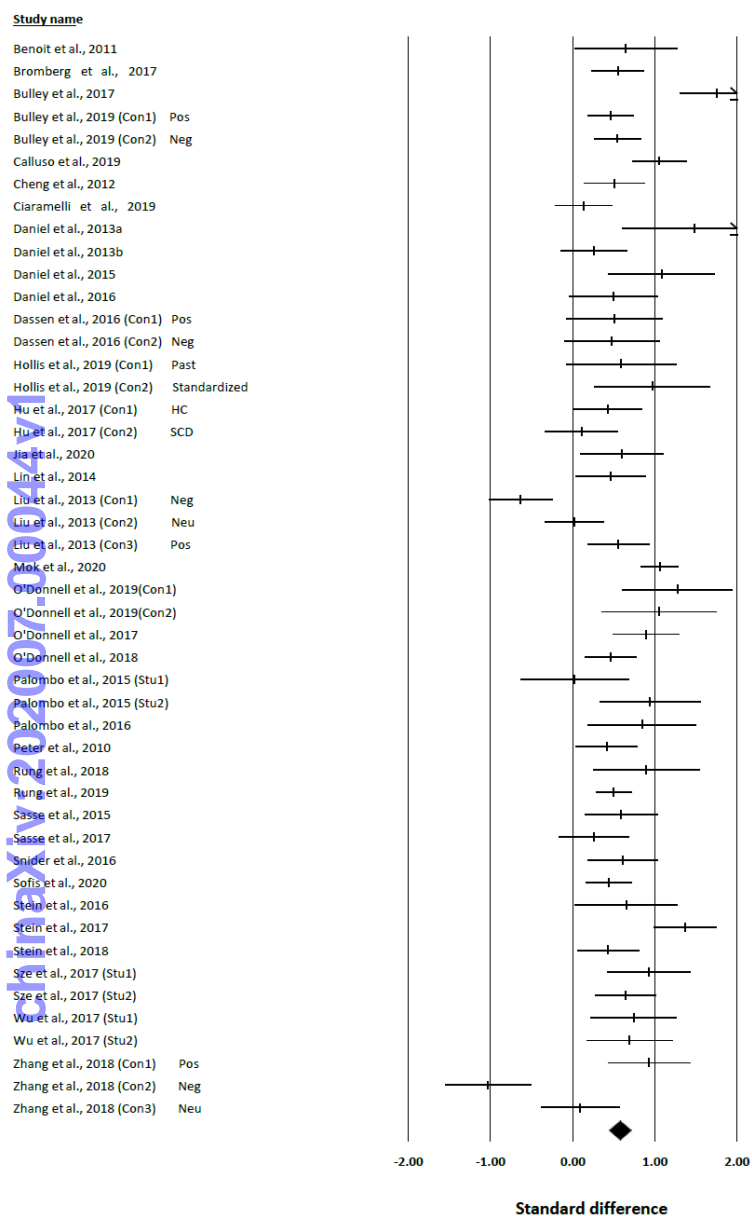


Fig. 2 The forest plot of the overall effect of EFT on DD.

*Note:* Con=Contrast; Stu= Study; HC=Healthy population; SCD=Subjective cognitive decline; Pos=Positive; Neu=Neutral; Neg=Negative; Past= Control task of recall past events; Standardized= Control task of Standardized episodic thinking; EFT = episodic future thinking; DD = delay discounting.

Table 1 Descriptions of studies included in the meta-analysis

Study	Participan ts	EFT group	Control group	EFT related moderators				Control task related moderators				DD related moderators						Main results
		N (Age)	N (Age)	EFT metho d	EFT event type	EFT valence	EFT longest days	Control event type	Control valence	Control longest days	DD paradig m type	Money type	Immedi ate reward	Delayed reward	DD longest delay	Largest money	DD index	
Benoit et al. (2011)	HC	12 (27.3)		Cue word	Task-related		1 year	Objectiv e usage			Fixed	HYP DD	Fixed	Variable	1 year	65	LLR%	↓
Bromberg et al. (2017)	HC	44 (13- 16)		Time period	Personally relevant	Positive and neutral	7 months	Visual perceptu al			Variable	PR DD	Fixed	Variable	7 months	50	AUC log k	↓
Bulley et al. (2017)	HC	48 (20.67)		Time period	Personally relevant	Positive	1 year	Story- telling			Variable	HYP DD	Variable	Fixed	1 year	10	AUC	↓
Bulley et al. (2019)	HC	99 (19.56)	101 (19.66)	Cue word	Personally relevant	Positive		Routine events	Neutral		Fixed	HYP DD	Variable	Variable	182 days	85	k log K LLR%	↓
	HC	97 (19.96)				Negative												↓
Calluso et al. (2019)	HC	55 (23.87)		Time period	Personally relevant	Positive	6 months	No			Fixed	HYP DD	Fixed	Variable	6 months	60	AUC k	↓
						Negative					Fixed	HYP DD			6 months		AUC k	↓
						Neutral					Fixed	HYP DD			6 months		AUC k	↓
Cheng et al. (2012)	HC	32 (21.1)	32	Time period	Personally relevant	Positive	4 years	Routine events	Neutral		Variable	HYP DD	Variable	Variable	7 days	15	interes t rate (%)	↓
Ciaramelli et al. (2019)	HC	59 (35.4)		Time period	Personally relevant	Positive and neutral	3 years	Past event	Positive and neutral	3 years	Variable	HYP DD	Variable	Fixed	1 year	40	AUC	↓
								Scene			Variable	HYP DD			1 year		AUC	↓
								Present			Variable	HYP DD			1 year		AUC	↓

Daniel et al. (2013a)	Obesity HC	48		Time period	Personally relevant	Positive	2 years	Recent event		24 hours	Variable	HYP DD	Variable	Fixed	2 years	10 100	AUC	↓
Daniel et al. (2013b)	Obesity	14	12	Time period	Personally relevant	Positive	2 years	Recent event		24 hours	Variable	HYP DD	Variable	Fixed	2 years	10 100	AUC	↓
Daniel et al. (2015)	Obesity	21 (12.13)	21 (12.33)	Time period	Personally relevant	Positive	6 months	Recent event	Positive	24 hours	Variable	HYP DD	Variable	Fixed	6 months	50	AUC	↓
Daniel et al. (2016)	HC	27	27	Time period	Personally relevant	Positive	6 months	Recent event	Positive	24 hours	Variable	HYP DD	Variable	Fixed	6 months	50	AUC	↓
Dassen et al. (2016)	HC	23	24	Time period	Personally relevant		6 months	Recent event		30 days	Fixed	HYP DD	Variable	Variable	186 days	85	k	↓
		24	23	Time period	task related			Routine events			Fixed	HYP DD	Variable	Variable	186 days	85	k	↓
Hollis-Hansen et al. (2019)	HC	18 (29)	18 (31.9)	Time period	Personally relevant	Positive	1 year	Recent event		6 days	Variable	HYP DD	Variable	Fixed	2 years	100	AUC	↓
			17 (27.4)					Standar dized episodic thinking										↓
Hu et al. (2017)	HC	24 (68.29)		Time period	Personally relevant			No			Fixed	HYP DD	Fixed	Variable	1 year	200	AUC ln k	↓
	Subjective cognitive decline	20 (68.29)		Time period	Personally relevant						Fixed	HYP DD	Fixed	Variable	1 year	200	AUC ln k	→
Jia et al. (2020)	SPD	30 (20.07)	33 (20.94)	Time period	Personally relevant	Positive	1 year	Recent event	Positive	24 hours	Variable	HYP DD	Variable	Fixed	1 year	200 1000	AUC	↓
Lin et al. (2014)	HC	45 (42.8)	42 (39.58)	Cue word		Positive and neutral	6 months	Recent event	Positive and neutral	24 hours	Fixed	HYP DD	Variable	Variable	187 days	86	ln k	↓
Liu et al. (2013)	HC	32 (20.62)		Cue word	Personally relevant	Positive		No			Variable	PR DD	Variable	Variable	30 days	30	delaye d	↓

Table 1. Summary of the studies included in the meta-analysis																		
Study	Group	Sample size (n)		Task	Stimulus	Outcome	Time	Event	Stimulus	Time	Task	Stimulus	Task	Time	Time	Time	Time	Time
		n																
Mok et al. (2020)	HC	30	(21.48)	Cue word	Personally relevant	Neutral		No			Variable	PR DD	Variable	Variable	30 days	30	rewards delay	→
	HC	31	(20.74)	Cue word	Personally relevant	Negative		No				PR DD	Variable	Variable	30 days	10-30	rewards delay	↑
Mok et al. (2020)	HC	114		Cue word	Personally relevant	Positive and neutral		No			Variable	HYP DD	Variable	Fixed	10 years	100 2000	AUC	↓
O'Donnell et al. (2017)	HC	52	52 (22.3) (22.2)	Time period	personal goal	Positive	2 years	Recent event	Positive	86 hours	Variable	HYP DD	Variable	Fixed	2 years	100	AUC	↓
O'Donnell et al. (2018)	HC	80 (35)	80 (34)	Time period	Personally relevant	Positive	2 years	Recent event	Positive	86 hours	Variable	HYP DD	Variable	Fixed	2 years	100	AUC	↓
O'Donnell et al. (2019)	HC	22	20 (45.17) (41.54)	Time period	Personally relevant	Positive	2 years	Recent event	Positive	86 hours	Variable	HYP DD	Variable	Fixed	2 years	100	AUC	↓
	HC	18	18 (41.72) (35.17)	Time period	Personally relevant	Positive	2 years	Recent event	Positive	86 hours	Variable	HYP DD	Variable	Fixed	2 years	100	AUC	↓
Palombo et al. (2015)	Amnesia	9		Time period	task related		2 years	No		2 years	Fixed	HYP DD	Fixed	Variable	2 years	58	LLR%	↓
	HC	13 (65)		Time period	task related		2 years	No		2 years	Fixed	HYP DD	Fixed	Variable	2 years	58	LLR%	↓
Palombo et al. (2016)	HC	12	(60.2)	Time period	task related		2 years	No			Fixed	HYP DD	Fixed	Variable	3 years	59	LLR%	↓
Peters et al. (2010)	HC	30 (25)		Time period	Personally relevant		7 months	No			Fixed	PR DD	Fixed	Variable	233 days	170	log k	↓

Rung et al. (2018)	HC	22 (33)	25 (34)	Time period	Personally relevant		1 year	Recent event		24 hours	Fixed	HYP DD	Variable	Fixed	1 year	100	Ratio of choos e larger rewar d	↓
Rung et al. (2019)	HC	176	174	Time period	Personally relevant	Positive	5 years	Recent event		24 hours	Variable	HYP DD	Variable	Fixed	1 year	100	IP	↓
Sasse et al. (2015)	HC	23 (24.96)		Time period	task related		190 days	No	No		Variable	PR DD	Fixed	Variable	190 days	79.5	k	↓
Sasse et al. (2017)	HC	66.55(4.02)	22	Time period	task related		190 days	No	No		Variable	PR DD	Fixed	Variable	190 days	79.5	k	→
Snider et al. (2016)	Alcoholic	25 (38)	25 (44.3)	Time period	Personally relevant	Positive	1 year	Past	Positive	24 hours	Variable	HYP DD	Variable	Fixed	1 year	100	AUC	↓
Sofis et al. (2020)	Cannabis use disorder	35.1 (9)	34.4 (10.5)	Time period	Personally relevant		1 year	Past		24 hours	Variable	HYP DD	Fixed	Variable	1 year	1000	AUC	↓
Stein et al. (2016)	Smoker	20 (38.65)	22 (39.86)	Time period	Personally relevant	Positive	1 year	Recent event		24 hours	Variable	HYP DD	Variable	Fixed	1 year	1000	AUC	↓
Stein et al. (2017)	HC	67 (36.67)	64 (34.79)	Time period	Personally relevant	Positive	1 year	Recent event	Positive	12 days	Variable	HYP DD	Variable	Fixed	25 years	100	ln k	↓
Stein et al. (2018)	HC	54	59	Time period	Personally relevant	Positive	1 year	Recent event	Positive	12 days	Variable	HYP DD	Variable	Fixed	25 years	100	ln k	↓
Sze et al. (2017)	HC	33	33	Time period	Personally relevant	Positive	6 months	Recent event	Positive	6 days	Fixed	HYP DD	Variable	Variable	182 days	85	log k	↓
	HC	34	34	Time period	Personally relevant	Positive	6 months	Recent event	Positive	6 days	Fixed	HYP DD	Variable	Fixed	1 year	100	AUC	↓
Wu et al. (2017)	HC	30	30	Time period	Personally relevant	Positive	1 year	ideal self		1 year	Fixed	PR DD	Fixed	Variable	1 year	240	k	↓
			30			Positive		No			Fixed	PR DD	Fixed	Variable	1 year	240	k	↓
	HC	30	30	Time period	Personally relevant	Positive	1 year	unperso nal EFT			Fixed	PR DD	Fixed	Variable	1 year	240	k	↓

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		30			Positive	routine event	Fixed	PR DD	Fixed	Variable	1 year	240	k	↓
Zhang et al. (2018)	HC	34 (21.53)	Cue word	Personally relevant	Positive	No	Fixed	PR DD	Fixed	Variable			log k	↓
		32 (21.53)	Cue word	Personally relevant	Negative	No	Fixed	PR DD	Fixed	Variable			log k	↑
		34 (21.19)	Cue word	Personally relevant	Neutral	No	Fixed	PR DD	Fixed	Variable			log k	→

*Note:* EFT= Episodic future thinking; DD=Delay discounting; HC=Healthy population; HYP DD= Hypothetical delay discounting task; PR DD=Potentially real delay discounting task; LLR=Larger later reward; IP = Indifference points; ↓ = delay discounting decreased; ↑ = delay discounting increased; →= No changes in delay discounting.

Table 2 The effect of EFT related moderators on DD

	<i>K</i>	<i>d</i>	<i>Z</i>	<i>p</i>	95% CI	<i>Q</i>	<i>p</i>	Fail-safe N
The EFT valence								
Positive	27	0.78	11.14	< 0.001	(0.64, 0.91)			2144
Not particularly mentioned	12	0.44	6.52	< 0.001	(0.31, 0.57)			121
Total between						12.09	0.001	
The method to elicit EFT								
Cue word task	17	0.36	2.86	0.004	(0.11, 0.61)			255
Time period task	27	0.72	9.34	< 0.001	(0.57, 0.87)			1808
Total between						5.86	0.016	
The context type of EFT								
Personally relevant	41	0.59	8.14	< 0.001	(0.45, 0.73)			3250
Task related	7	0.52	4.49	0.004	(0.29, 0.74)			38
Total between						0.25	0.616	
The longest delay in EFT								
≤180 days	7	0.75	7.14	< 0.001	(0.54, 0.95)			121
180<X≤365 days	17	0.71	7.33	< 0.001	(0.52, 0.90)			664
>365 days	12	0.61	5.89	< 0.001	(0.41, 0.81)			257
Total between						0.95	0.623	

Note: EFT = episodic future thinking; DD = delay discounting.

Table 3 The effect of control task related moderators on DD

	<i>K</i>	<i>d</i>	<i>Z</i>	<i>p</i>	95% CI	<i>Q</i>	<i>p</i>	Fail-safe N
The control task valence								
Positive	13	0.75	8.31	< 0.001	(0.57, 0.93)			516
Not particularly mentioned	34	0.51	5.79	< 0.001	(0.34, 0.69)			1469
Total between						3.46	0.063	
The context type of control task								
Past event	19	0.67	8.56	< 0.001	(0.51, 0.82)			814
No control task	18	0.40	2.94	0.003	(0.13, 0.68)			315
Other types	15	0.60	5.95	< 0.001	(0.40, 0.80)			418
Total between						2.86	0.239	
The longest time distance of control task								
<24 hours	8	0.55	8.04	< 0.001	(0.42, 0.69)			126
>24 hours	11	0.72	5.53	< 0.001	(0.46, 0.97)			289
Total between						1.26	0.261	

Note: DD = delay discounting.

Table 4 The effect of DD task related moderators on DD

	<i>K</i>	<i>d</i>	<i>Z</i>	<i>p</i>	95% CI	<i>Q</i>	<i>p</i>	Fail-safe N
The DD money type								
Hypothetical money	36	0.68	10.82	< 0.001	(0.56, 0.81)			3157
Potentially real money	12	0.26	1.71	0.087	(-0.04, 0.57)			45
Total between						6.32	0.012	
The DD task type								
Fixed money	20	0.52	5.27	< 0.001	(0.32, 0.71)			474
Variable money	28	0.62	7.12	< 0.001	(0.45, 0.80)			1719
Total between						0.68	0.411	
The immediate reward type								
Variable immediate reward	31	0.65	7.92	< 0.001	(0.49, 0.80)			2131
Fixed immediate reward	17	0.46	4.19	< 0.001	(0.24, 0.67)			290
Total between						1.89	0.170	
The delayed reward type								
Variable delayed reward	27	0.42	5.14	< 0.001	(0.26, 0.59)			700
Fixed delayed reward	21	0.78	8.37	< 0.001	(0.60, 0.97)			1352
Total between						8.29	0.004	
The outcome index of DD								
Area under curve	22	0.73	8.23	< 0.001	(0.55, 0.90)			1329
K	19	0.47	4.88	< 0.001	(0.28, 0.65)			432
Total between						3.98	0.046	
The longest delay of DD								
≤180 days	8	0.45	2.13	0.033	(0.04, 0.86)			58
180<X≤365 days	22	0.56	8.68	< 0.001	(0.43, 0.68)			910
>365 days	15	0.79	7.41	< 0.001	(0.58, 1.00)			627
Total between						4.21	0.122	
The largest money reward of DD								
<100	25	0.55	5.97	< 0.001	(0.37, 0.73)			935
≥100	23	0.68	9.46	< 0.001	(0.54, 0.82)			1348
Total between						1.16	0.281	

Note: DD = delay discounting.

Table 5 The effect of information of participants related moderators on reducing DD

	<i>K</i>	<i>d</i>	<i>Z</i>	<i>p</i>	95% CI	<i>Q</i>	<i>p</i>	Fail-safe N
The age of participants								
≤ 40 years old	39	0.58	7.96	< 0.001	(0.43, 0.72)			2631
>40 years old	9	0.60	3.84	< 0.001	(0.29, 0.90)			144
Total between						0.02	0.898	
The population of participants								
Healthy individuals	40	0.59	8.06	< 0.001	(0.45, 0.73)			3059
Special populations	8	0.50	3.93	< 0.001	(0.25, 0.75)			64
Total between						0.35	0.556	

Note: DD = delay discounting.

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